What is claimed is:

1. A CVI/CVD process, comprising the steps of:

partially densifying a porous structure within a CVI/CVD furnace by depositing a first matrix within said porous structure with a pressure gradient CVI/CVD process in which a first portion of said porous structure is subjected to a greater pressure than a second portion of said porous structure and said first portion has a greater bulk density gain than said second portion; and, 427

subsequently densifying said porous structure by depositing a second matrix within said porous structure with at least one additional densification process in which said second portion has a greater bulk density gain than said first portion.

2. The process of claim 1, wherein said additional densification process is a conventional CVI/CVD process.

3. The process of claim 1, wherein said additional densification process is a pressure gradient CVI/CVD process in which said second portion is subjected to a higher pressure than said first portion.

4. The process of claim 1, wherein said additional densification process is a resin impregnation process, and further comprising the step of charring said resin. 427 226F

5. The process of claim 1, further comprising the step of heat treating said partially densified porous structure at a temperature greater than said pressure gradient CVI/CVD process before said step of subsequently densifying the porous structure by at least one additional densification process.

6. The process of claim 1, wherein said porous structure is a carbon porous structure and said pressure gradient CVI/CVD process deposits a carbon

matrix within said porous structure.

7. The process of claim 1, wherein said porous structure is annular and has two generally planar opposing surfaces, and said first portion includes one of said two opposing surfaces, and said second portion includes the other of said two opposing surfaces.

8. The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

9. The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said outside circumferential surface, and said second portion includes said inside circumferential surface.

10. The process of claim 1, wherein said porous structure is annular and has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

11. The process of claim 1, wherein said porous structure is annular and has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said inside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said outside circumferential surface and the other of said two generally parallel planar surfaces.

12. The process of claim 1, wherein said

porous structure is annular and has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said outside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said inside circumferential surface and the other of said two generally parallel planar surfaces.

13. The process of claim 1, further comprising the step of heat treating said porous structure at a temperature greater than said pressure gradient CVI/CVD process after said pressure gradient CVI/CVD process and before said step of subsequently densifying said porous structure.

14. The process of claim 1, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous structure from said CVI/CVD furnace.

15. A CVI/CVD process, comprising the steps of:

partially densifying a multitude of annular fibrous carbon structures within a CVI/CVD furnace by depositing a first carbon matrix within said annular fibrous carbon structure with a pressure gradient CVI/CVD process in which a first portion of each annular fibrous carbon structure is subjected to a higher pressure than a second portion of each annular fibrous carbon structure and said first portion has a greater bulk density gain than said second portion; and,

subsequently densifying said multitude of annular fibrous carbon structures by depositing a second carbonaceous matrix within each annular fibrous carbon structure with at least one additional densification process in which said second portion has a greater bulk

density gain than said first portion.

16. The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces, and said first portion includes one of said two generally parallel planar surfaces, and said second portion includes the other of said two generally parallel planar surfaces.

17. The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

18. The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, and said first portion includes said outside circumferential surface, and said second portion includes said inside circumferential surface.

19. The process of claim 15, wherein each annular fibrous carbon structure has an inside circumferential surface and an outside circumferential surface, and said first portion includes said inside circumferential surface, and said second portion includes said outside circumferential surface.

20. The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said inside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said outside circumferential surface and the other of said two generally parallel planar surfaces.

21. The process of claim 15, wherein each annular fibrous carbon structure has two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, and said first portion includes said outside circumferential surface and one of said two generally parallel planar surfaces, and said second portion includes said inside circumferential surface and the other of said two generally parallel planar surfaces.

22. The process of claim 15, further comprising the step of heat treating said annular fibrous carbon structure at a temperature greater than said pressure gradient CVI/CVD process after said pressure gradient CVI/CVD process and before said step of subsequently densifying said annular fibrous carbon structure.

23. The process of claim 22, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous structure from said CVI/CVD furnace.

24. A CVI/CVD process, comprising the steps of:

heating a porous carbon structure to a temperature of at least 1750 °F;

heating a hydrocarbon reactant gas to a temperature of at least 1650 °F;

partially densifying said porous carbon structure by forcing said reactant gas to pass through said porous carbon structure from a first portion of said fibrous structure to a second portion of said porous carbon structure, said first portion having a greater bulk density gain than said second portion; and,

subsequently densifying said porous carbon

structure by depositing a second matrix within said porous carbon structure with at least one additional densification process in which said second portion has a greater bulk density gain than said first portion.

25. The process of claim 24, wherein said second matrix is a carbon matrix and said additional densification process is a conventional CVI/CVD process.

26. The process of claim 24, wherein said additional densification process comprises the steps of:

heating a porous carbon structure to a temperature of at least 1750 °F;

heating a hydrocarbon reactant gas to a temperature of at least 1650 °F; and,

passing said reactant gas around said porous structure.

27. The process of claim 24, further comprising the step of heat treating said porous carbon structure at a temperature of at least 3300 °F after said step of partially densifying said porous carbon structure and before said step of subsequently densifying said porous carbon structure.

28. The process of claim 27, wherein said step of heat treating said porous structure follows said pressure gradient CVI/CVD process without removing said porous carbon structure from said CVI/CVD furnace.

29. A product made by the process of claim 1.

30. A product made by the process of claim 13.

31. A product made by the process of claim 15.

32. A product made by the process of claim 22.

33. A product made by the process of claim 24

34. A product made by the process of claim 27.

~~35. A friction disk,~~ comprising:

a densified annular porous structure having a first carbon matrix deposited within said annular porous structure and a second carbon matrix deposited within said annular porous structure overlying said first carbon matrix, said densified annular porous structure having two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, a first circumferential portion adjacent said inside circumferential surface, and a second circumferential portion adjacent said outside circumferential surface, wherein said first and second circumferential portions are bounded by said two generally parallel planar surfaces, said second circumferential portion having at least 10% less of said first carbon matrix per unit volume relative to said first circumferential portion, said first carbon matrix and said second carbon matrix having a substantially rough laminar microstructure, and said first carbon matrix being more graphitized than said second carbon matrix.

36. The friction disk of claim 35, wherein said first carbon matrix and said second carbon matrix have at least 90% rough laminar microstructure.

37. The friction disk of claim 35, wherein said first carbon matrix and said second carbon matrix have at least 95% rough laminar microstructure.

38. The friction disk of claim 35, wherein said first circumferential portion has a greater thermal conductivity normal to said two generally parallel planar surfaces than said second circumferential portion.

39. The friction disk of claim 35, wherein said first circumferential portion has a greater thermal conductivity normal to said first and second

circumferential surfaces than said second circumferential portion.

40. The friction disk of claim 35, wherein said first circumferential portion has a greater crushed apparent density than said second circumferential portion.

41. The friction disk of claim 35, wherein said first circumferential portion with has a crushed apparent density at 0.2% greater than said second circumferential portion.

42. The friction disk of claim 35, wherein said first carbon matrix has a greater thermal conductivity than said second carbon matrix.

43. The friction disk of claim 35, wherein said first carbon matrix has a greater density than said second carbon matrix.

44. The friction disk of claim 35, wherein said annular porous structure comprises carbon fibers.

45. The friction disk of claim 35, wherein said densified annular porous structure comprises an annular fibrous structure.

46. The friction disk of claim 35, wherein said densified annular porous structure comprises an annular fibrous structure having carbon fibers.

47. The friction disk of claim 46, wherein said first circumferential portion has a greater thermal conductivity normal to said two generally parallel planar surfaces than said second circumferential portion.

48. The friction disk of claim 46, wherein said first circumferential portion has a greater thermal conductivity normal to said first and second circumferential surfaces than said second circumferential portion.

49. The friction disk of claim 46, wherein said first circumferential portion has a greater crushed

apparent density than said second circumferential portion.

50. The friction disk of claim 35, wherein said densified annular porous structure comprises an annular fibrous structure having only carbon fibers.

51. A friction disk, comprising:

a densified annular fibrous structure having a first carbon matrix deposited within said annular porous structure and a second carbon matrix deposited within said annular porous structure overlying said first carbon matrix, said densified annular porous structure having two generally parallel planar surfaces bounded by an inside circumferential surface and an outside circumferential surface spaced from and encircling said inside circumferential surface, a first circumferential portion adjacent said inside circumferential surface, and a second circumferential portion adjacent said outside circumferential surface, wherein said first and second circumferential portions are bounded by said two generally parallel planar surfaces, said second circumferential portion having at least 10% less of said first carbon matrix per unit volume relative to said first circumferential portion, said first carbon matrix and said second carbon matrix having a substantially rough laminar microstructure, and said first carbon matrix being more graphitized than said second carbon matrix;

wherein thermal conductivity normal to said two opposing surfaces and crushed apparent density of said densified annular porous structure generally decrease in a radial direction from said inside circumferential surface to said outside circumferential surface.

52. The friction disk of claim 51, wherein said densified annular fibrous structure comprises carbon fibers.

53. A CVI/CVD process in a CVI/CVD furnace, comprising the steps of:

introducing a reactant gas into a sealed preheater disposed within said CVI/CVD furnace, said sealed preheater having a preheater inlet and a preheater outlet, said reactant gas being introduced into said preheater inlet and exiting said sealed preheater through said preheater outlet and infiltrating at least one porous structure disposed within said CVI/CVD furnace;

heating said at least one porous structure;

heating said sealed preheater to a preheater temperature greater than said reactant gas temperature;

sensing a gas temperature of said reactant gas proximate said outlet;

adjusting said preheater temperature to achieve a desired gas temperature; and,

exhausting said reactant gas from said CVI/CVD furnace.

54. The process of claim 53, wherein said CVI/CVD furnace comprises a susceptor wall, and further comprising the step of heating said susceptor wall, and said step of heating said sealed preheater comprises the step of radiating heat energy from said susceptor wall to said sealed preheater.

55. The process of claim 53, wherein said sealed preheater is disposed in close proximity to said susceptor wall.

56. The process of claim 53, wherein said CVI/CVD furnace comprises a susceptor wall having at least first and second susceptor wall portions and at least first and second induction coils, said first induction coil being inductively coupled to said first susceptor wall in a manner that transforms electrical energy from said first induction coil to heat energy in said first susceptor wall, and said second induction

coil being inductively coupled to said second susceptor wall portion in a manner that transforms electrical energy from said second induction coil to heat energy in said second susceptor wall portion, said sealed preheater being disposed proximate said first susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first susceptor wall portion; and

wherein said step of adjusting said heat exchanger temperature comprises the step of adjusting electrical power to said first induction coil.

57. The process of claim 53, wherein said CVI/CVD furnace comprises a cylindrical susceptor wall having at least first and second cylindrical susceptor wall portions and at least first and second cylindrical induction coils, said first cylindrical induction coil being concentrically disposed around and inductively coupled to said first cylindrical susceptor wall in a manner that transforms electrical energy from said first cylindrical induction coil to heat energy in said first cylindrical susceptor wall, and said second cylindrical induction coil being concentrically disposed around and inductively coupled to said second cylindrical susceptor wall portion in a manner that transforms electrical energy from said second cylindrical induction coil to heat energy in said second cylindrical susceptor wall portion, said sealed preheater defines a generally cylindrical preheater perimeter concentrically disposed within and in close proximity to said first cylindrical susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first cylindrical susceptor wall portion; and

wherein said step of adjusting said preheater temperature comprises the step of adjusting electrical power to said first induction coil.

58. The process of claim 53, wherein said CVI/CVD furnace comprises a generally cylindrical susceptor wall, and said sealed preheater comprises a generally arcuate preheater perimeter in close proximity to said cylindrical susceptor wall.

59. The process of claim 53, wherein said sealed preheater is resistance heated by electrical energy.

60. The process of claim 53, wherein said preheater outlet comprises an array of perforations.

61. The process of claim 53, wherein said at least one porous structure comprises a first portion and a second portion; and,

further comprising the step of forcing said reactant gas to pass through said at least one porous structure from said first portion to said second portion.

62. The process of claim 61, wherein said reactant gas deposits a carbon matrix having a substantially rough laminar microstructure within said at least one porous structure.

63. The process of claim 53, wherein said at least one porous structure is a carbon porous structure, and said reactant gas deposits a carbon matrix within said at least one porous structure.

64. The process of claim 53, wherein said at least one porous structure comprises a plurality of annular porous structures disposed in a stack that defines an annular porous wall; and,

further comprising the step of forcing dispersion of said reactant gas through said annular porous wall by introducing said reactant gas to said CVI/CVD furnace and exhausting said reactant gas from said CVI/CVD furnace on opposite sides of said annular porous wall.

65. The process of claim 64, wherein each

annular porous structure has a surface area, said stack of annular porous structures having at least one ring concentrically disposed between each pair of adjacent porous structures with a majority of said surface area of each annular porous structure being exposed to said reactant gas.

66. The process of 64, wherein said stack defines an enclosed cavity bounded by said annular porous wall; and,

further comprising the step of introducing said reactant gas from said preheater outlet into said enclosed cavity, said enclosed cavity being sealed to said preheater outlet.

67. A CVI/CVD process in a CVI/CVD furnace, comprising the steps of:

forming an annular porous wall that defines an enclosed cavity, said porous annular wall including a stack of annular fibrous carbon structures;

sealing said annular porous wall to a sealed preheater, said sealed preheater having a preheater inlet and a preheater outlet, said enclosed cavity being in fluid communication with said gas outlet;

introducing a carbon bearing reactant gas into said preheater inlet, directing said gas through said sealed preheater, to said preheater outlet, and into said enclosed cavity;

heating said annular porous wall;

heating said preheater to a preheater temperature greater than a gas temperature of said reactant gas proximate said preheater inlet;

sensing a gas temperature of said reactant gas proximate said preheater outlet;

adjusting said preheater temperature to achieve a desired gas temperature; and,

withdrawing said reactant gas from said CVI/CVD furnace on a side of said annular porous wall

opposite said enclosed cavity thereby forcing dispersion of said reactant gas introduced into said enclosed cavity through said annular porous wall.

68. The process of claim 67, wherein said CVI/CVD furnace comprises a susceptor wall having at least first and second susceptor wall portions and at least first and second induction coils, said first induction coil being inductively coupled to said first susceptor wall in a manner that transforms electrical energy from said first induction coil to heat energy in said first susceptor wall, and said second induction coil being inductively coupled to said second susceptor wall portion in a manner that transforms electrical energy from said second induction coil to heat energy in said second susceptor wall portion, said preheater being disposed proximate said first susceptor wall portion and being heated to said preheater temperature at least in part by radiant heat energy from said first susceptor wall portion; and

wherein said step of adjusting said preheater temperature comprises the step of adjusting electrical power to said first induction coil.

69. The process of claim 67, wherein said reactant gas deposits a carbon matrix having a substantially rough laminar microstructure within said annular porous wall.

70. The process of claim 67, wherein each annular fibrous carbon structure has a surface area, said stack having at least one ring concentrically disposed between each pair of adjacent annular fibrous carbon structures with a majority of said surface area of each annular fibrous carbon structure being exposed to said reactant gas.

~~71. An apparatus for introducing a first reactant gas into a CVI/CVD furnace, comprising:~~

a first main gas line for supplying the first reactant gas;

a plurality of furnace supply lines in fluid communication with said first main gas line and the CVI/CVD furnace;

a plurality of first flow meters that measure a quantity of first reactant gas flow through each furnace supply line; and,

a plurality of first control valves configured to control said quantity of flow of the first reactant gas through each furnace supply line.

72. The apparatus of claim 71, wherein said quantity of flow is different for each furnace supply line.

73. The apparatus of claim 71, wherein said plurality of first flow meters communicate with a controller, said controller controlling said plurality of first control valves.

74. The apparatus of claim 71, wherein each furnace supply line comprises one first flow meter and one first control valve, said one first flow meter communicating with a controller, said controller controlling said one first control valve.

75. The apparatus of claim 71, further comprising a first main control valve disposed within said first main gas line.

76. The apparatus of claim 71, wherein a second reactant gas is supplied to the CVI/CVD furnace, further comprising:

a second main gas line for supplying the second reactant gas;

a plurality of second flow meters that measure a quantity of second reactant gas flow through each furnace supply line; and,

a plurality of second control valves configured to control said quantity of flow of the

second reactant gas through each furnace supply line.

77. An apparatus for CVI/CVD densifying a plurality of porous structures, comprising:

a CVI/CVD furnace that defines a furnace volume;

a vacuum apparatus in fluid communication with said furnace volume;

a first main gas line for supplying a first reactant gas;

a plurality of furnace supply lines in fluid communication with said first main gas line; and,

a plurality of stacks of the porous structures disposed within said furnace volume, each stack defining an enclosed cavity in fluid communication with a different furnace supply line and sealed within said furnace volume such that a reactant gas flow introduced into each enclosed cavity through said one furnace supply line is forced to disperse through said porous structures before being withdrawn from said furnace volume by said vacuum apparatus.

78. The apparatus of claim 77, further comprising a first main control valve disposed within said first main supply line.

79. The apparatus of claim 77, further comprising:

a plurality of first flow meters that measure a quantity of first reactant gas flow through each furnace supply line; and,

a plurality of first control valves configured to control said quantity of flow of the first reactant gas through each furnace supply line.

80. The apparatus of claim 79, wherein said quantity of first reactant gas flow is different for each furnace supply line.

81. The apparatus of claim 78, wherein each furnace supply line comprises one first flow meter and

one first control valve, said one first flow meter communicating with a controller, said controller controlling said one first control valve.

82. The apparatus of claim 78, further comprising:

a second main gas line for supplying a second reactant gas, said furnace supply lines being in fluid communication with said second main gas line.

83. The apparatus of claim 82, further comprising:

a plurality of second flow meters that measure a quantity of second reactant gas flow through each furnace supply line; and,

a plurality of second control valves configured to control said quantity of flow of said second reactant gas through each furnace supply line.

84. A CVI/CVD densification process, comprising the steps of:

densifying a first porous wall within a CVI/CVD furnace by a pressure gradient CVI/CVD process wherein a first flow of reactant gas is forced to disperse through said first porous wall;

densifying a second porous wall by a pressure gradient CVI/CVD process wherein a second flow of reactant gas is forced to disperse through said second porous wall; and,

independently controlling said first flow of said reactant gas and said second flow of said reactant gas.

85. The process of claim 84, further comprising the steps of:

densifying at least a third porous wall by a pressure gradient CVI/CVD process wherein at least a third flow of reactant gas is forced to disperse through at least said third porous wall; and

independently controlling at least said third

flow of reactant gas.

86. The process of claim 84, further comprising the steps of:

sensing a first porous wall temperature; and,

controlling said first porous wall temperature by increasing or decreasing said first flow of reactant gas.

87. The process of claim 86, further comprising the steps of:

sensing a second porous wall temperature; and,

controlling said second porous wall temperature by increasing or decreasing said second flow of reactant gas.

88. The process of claim 84, wherein:

said step of densifying said first porous wall includes the step of subjecting one side of said first porous wall to said first flow of reactant gas at a first pressure and an opposing side of said first porous wall to a vacuum pressure, said first pressure being greater than said vacuum pressure; and,

said step of densifying said second porous wall includes the step of subjecting one side of said second porous wall to said second flow of reactant gas at a second pressure and an opposing side of said second porous wall to a vacuum pressure, said second pressure being greater than said vacuum pressure

89. The process of claim 88, further comprising the steps of:

sensing said first pressure; and,

controlling said first pressure by increasing or decreasing said first flow of reactant gas.

90. The process of claim 89, further comprising the steps of:

sensing said second pressure; and,

controlling said second pressure by increasing or decreasing said second flow of reactant gas.